i2X Studies, Tools, and Interconnection Consistency and Harmonization Kick-Off Meeting

i2X STITCH | 05/26/2026

ESIG

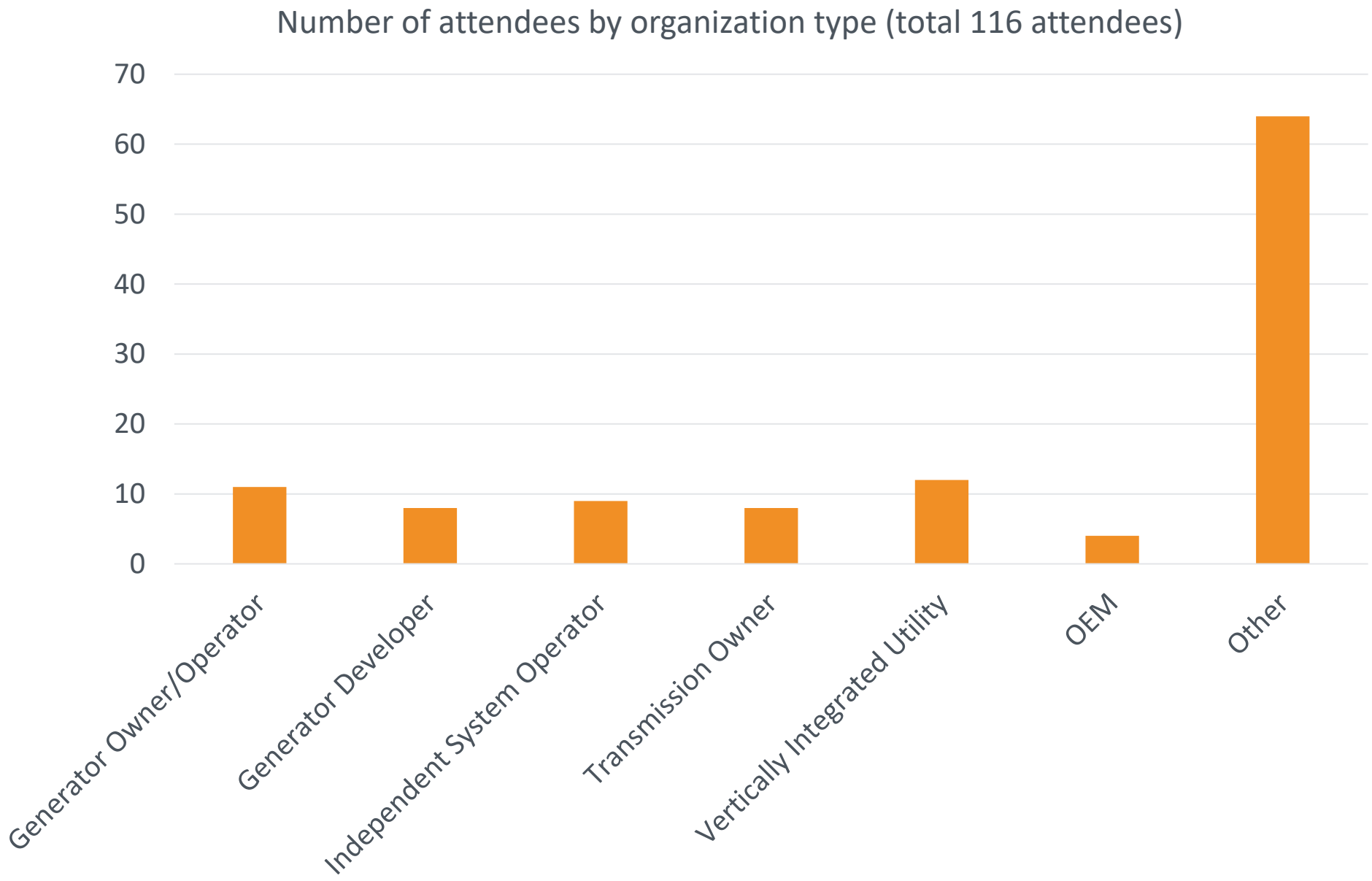
ELEVATE ENERGY CONSULTING

BERKELEY LAB

i2X INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

A DOE initiative supported by the Office of Critical Minerals and Energy Innovation (CMEI)

The first half of this meeting is being recorded and may be posted on ESIG's website. If you do not wish to have your voice recorded, please do not speak during the call. If you do not wish to have your image recorded, please turn off your camera or participate by phone. If you speak during the call or use a video connection, you are presumed consent to recording and use of your voice or image.



"Other" category includes Consultants, Research Organizations and Regulators

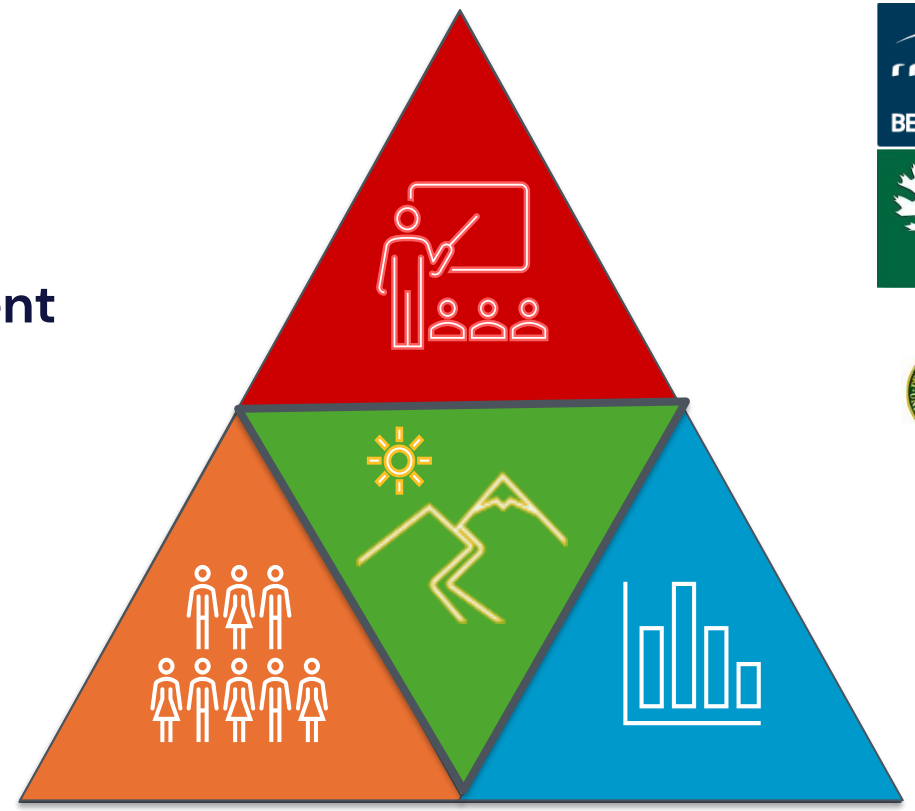
i2X STITCH May 26th Kick-Off – Agenda

1. **Introduction to the i2X Program and i2X STITCH:** Will Gorman, LBNL; Cindy Bothwell, DOE
2. **Relevant Data Trends and Motivation:** Joe Rand, LBNL
3. **Developer Perspective on Interconnection Studies and Tools:** Ajay Pappu, Invenergy
4. **Interconnection Studies Whitepaper - Introduction:** Sirisha Tanneeru, Elevate Energy Consulting
5. **Audience Q&A and Discussion**, led by Julia Matevosyan, ESIG

Interconnection Innovation e-Xchange (i2X) Program

Mission: To enable a **simple**, **fast**, and **affordable** interconnection while enhancing the **reliability** and **security** of our **electric grid.**

- **Strategic Solutions**
- **Stakeholder Engagement**
- **Data & Analytics**
- **Research & Innovation**



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U.S. Department of Energy | Office of Electricity

U.S. Department of Energy — Office of Cybersecurity, Energy Security, and Emergency Response

U.S. Department of Energy — Office of Technology Commercialization

Past i2X Activity Highlights

Strategic IX Solutions

- 60+ real-world solutions for transmission and distribution grid around 4 goals:
  - Increase Data Access and Transparency,
  - Improve Process and Timing
  - Promote Economic Efficiency in Interconnection
  - Maintain a Reliable, Resilient, and Secure Grid

Data & Analytics

- BPS interconnection cost reports for MISO, PJM, NYISO, SPP, and ISO-NE, plus a summary published (LBNL)
- 2025 Queued Up report on BPS interconnection timelines (LBNL)

Stakeholder Engagement

- Numerous events and presentations (e.g. NASUCA Mid-Year, RE+2025, FERC briefings) to disseminate solutions in our Roadmaps
- Four lab-hosted Solution e-Xchange webinars covering solutions for distributed energy interconnection
- i2X Forum for the Implementation of Reliability Standards for Transmission (i2X FIRST) with 1250 unique participants

Research & Innovation

- 5 utility projects through the iQMS PIA testing queue management improvements with Sandia + SEPA leading peer-learning and technical guidance for utilities
- Direct Transfer Trip White Paper (Sandia)
- ORNL /ESIG NERC training bootcamps for BPS grid engineers on using Electromagnetic Transient (EMT) modeling methods and techniques

i2X 2026 plans

Strategic IX Solutions

- Update solutions considering the changing interconnection landscape

Data & Analytics

- 2026 Queued Up report on BPS interconnection timelines (LBNL)

Stakeholder Engagement

- **i2X STITCH – Kick-Off Today!**
- i2X FIRST Season 3
- i2X FIRST Office Hours on BPS
- Electromagnetic transient (EMT) modeling methods and techniques training for BPS grid engineers

Research & Innovation

- White Papers to support stakeholder engagements
- SWIFTR Funding Opportunity projects
- Technical Assistance
- Interconnection Cost Reduction Strategies (iCRS)

Program Purpose

This Program will fund experts in bulk electric power system modeling and innovative transmission techniques (Voucher Providers) to provide services to transmission providers (**Voucher Recipients**).

Total Funding*

$4,000,000 to Voucher Providers

NOTE: Funding will directly reimburse Voucher Providers for work they complete on behalf of Voucher Recipients

Deadline - June 18, 2026 3:00 pm ET

Voucher Opportunity 11 - i2X Interconnection Cost Reduction Solutions for Transmission (iCRS-T) (Recipients)

Information

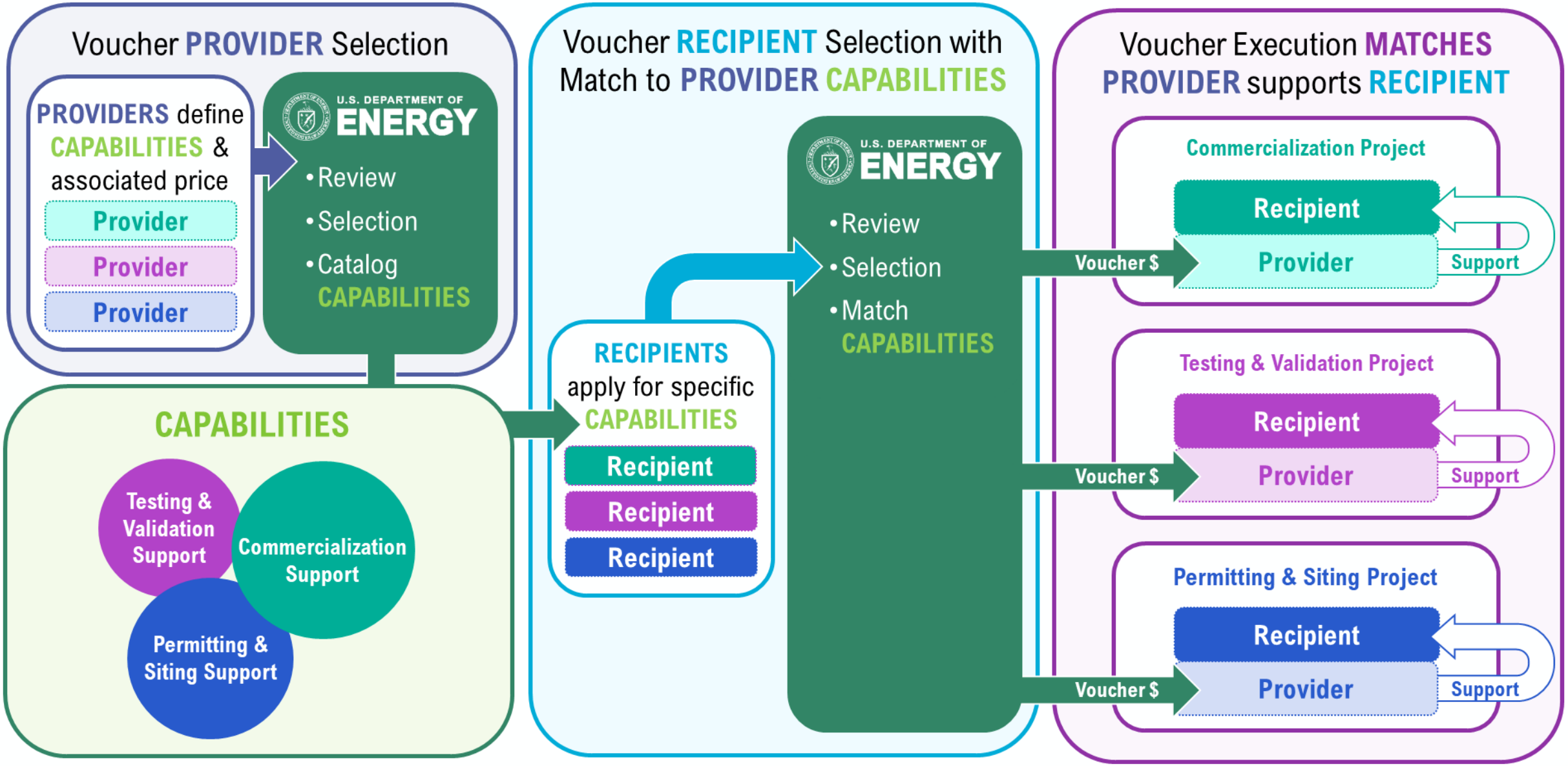
Description

The U.S. Department of Energy's (DOE) Interconnection Innovation e-Xchange (i2X) program is providing industry expertise to transmission owners and operators (transmission providers, Voucher Recipients) to increase their understanding and implementation of advanced interconnection topics with the goal of reducing transmission interconnection costs. Through the Interconnection Cost Reduction Solutions for Transmission (iCRS-T) Voucher Program, these industry experts (Voucher Providers) will assist transmission providers (Voucher Recipients) in modeling advanced transmission technologies and controls that are currently underutilized. These new modeling capabilities can give transmission providers more cost-saving options and either reduce the need for costly network upgrades or provide a faster path for interconnection alongside more extensive transmission upgrades. Additionally, Voucher Providers will train transmission providers in modeling innovative transmission technologies and controls, including incorporating these into electromagnetic transient (EMT) studies.

This Opportunity will open for Voucher Recipient applications on **May 5, 2026**, and applications will be accepted until **June 18, 2026**. This opportunity anticipates having matching completed in the Summer of 2026. DOE reserves the right to request additional information about applications prior to selection, if necessary. To receive reminders for this and future opportunities, sign up to Join Our Ecosystem.

For general information on Voucher Programs see Vouchers Overview.

Voucher Opportunity 11 - i2X Interconnection Cost Reduction Solutions for Transmission (iCRS-T) (Recipients) Jun 18, 2026


Voucher PROVIDER Selection
PROVIDERS define CAPABILITIES & associated price
Provider
Provider
Provider
U.S. DEPARTMENT OF ENERGY
• Review
• Selection
• Catalog CAPABILITIES
CAPABILITIES
Testing & Validation Support
Commercialization Support
Permitting & Siting Support
Voucher RECIPIENT Selection with Match to PROVIDER CAPABILITIES
RECIPIENTS apply for specific CAPABILITIES
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• Review
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• Match CAPABILITIES
Voucher Execution MATCHES PROVIDER supports RECIPIENT
Commercialization Project
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Permitting & Siting Project
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Vouchers will be distributed as in-kind support, meaning that ENERGYWERX will directly reimburse the Voucher Provider for the work they have completed on behalf of the Voucher Recipients.

Who can Apply as Recipients?

Voucher Recipient Applicant is a U.S.-based public or private firm that provides transmission as planners, owners, or operators to the U.S. bulk power system. Voucher Recipients should be responsible for modeling, maintaining, and upgrading the transmission system and have a need to advance their capabilities to affordably and reliably interconnect additional large loads, generation resources, storage devices, or hybrid combination.

Please see Eligibility Criteria on the Opportunity website.

energywerx

Voucher Capabilities

12 expert organizations in bulk electric power system modeling and innovative transmission techniques (Voucher Providers) offering **20+** relevant capabilities – visit the Voucher Capabilities site to see approved list.

See complete list of Voucher Capabilities
https://www.energywerx.org/vouchers/capabilities

- Voucher Provider Capability generally:
  - Modeling and implementation of applied grid solutions such as dynamic line ratings, alternative transmission technologies, and power flow controllers.
  - EMT modeling and dynamic simulation for large electronic loads, IBRs, and hybrids.
  - Incorporating large loads or advanced transmission technologies in interconnection requirements.
  - Advanced hosting capacity that includes strength or stability analysis.
  - Artificial intelligence supported interconnection studies.
  - Training associated with the above services.

Program Timeline

All dates are subject to change

Key Goals and Outcomes from i2X STITCH

- To advance interconnection study practices across U.S. regions by identifying opportunities for harmonization, standardization, and automation to improve the speed, transparency, and reliability of generation and storage interconnections.
- The Forum will convene the industry stakeholders and synthesize insights from meetings into a technical whitepaper that defines actionable pathways for consistent and efficient interconnection study processes nationwide.
- The presentation portion of these meetings will be recorded and posted, and presentation slides will be shared.
- Regional study processes, challenges and gaps, recommended practices and harmonization opportunities will be summarized in the whitepaper, published by the end of the meeting series, in February 2027

i2X STITCH Leadership Team

Cynthia Bothwell, DOE CMEI

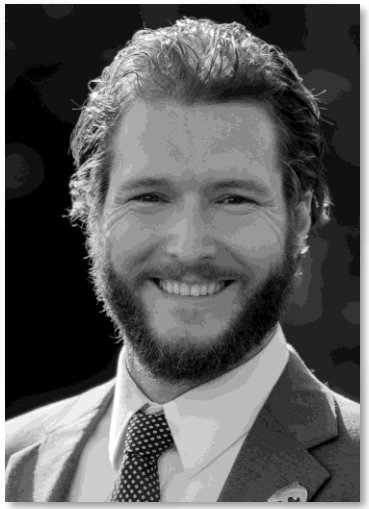
Jian Fu, DOE CMEI

Ammar Qusaibaty, DOE CMEI

Will Gorman, LBNL

Julia Matevosyan, Energy Systems Integration Group

Ryan Quint, Elevate Energy Consulting



Sirisha Tanneeru, Elevate Energy Consulting

i2X STITCH Meetings – Preliminary Agenda

1. **May 26th, 2026, 11 a.m.- 1 p.m. ET: Kick-Off Meeting**
2. June 23rd, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process (MISO, PJM)
3. July 28th, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process Cont. (SPP, ERCOT)
4. August 18th, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process Cont. (CAISO, WECC utility)
5. September 22nd, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process Cont. (NYISO, ISO-NE, non-ISO utility)
6. October 20th, 2026, 11 a.m.- 1 p.m. ET: Automation and Data Harmonization
7. November 17th, 2026, 11 a.m.- 1 p.m. ET: Industry Advisor Perspectives and Other Topics
8. January 26th, 2026, 11 a.m.- 1 p.m. ET: Final Paper Presentation
9. March 22nd, 2026, hybrid 1-day event during ESIG Spring Workshop, San Diego, California: Interconnection Studies and Harmonization Workshop

Follow ESIG i2X STITCH website: https://www.esig.energy/i2x-initiatives/#i2x-STITCH for meeting materials & recordings and for future meeting details, agendas, and to register!

Key questions we will pose (and hopefully answer)

In our regional presentations and meetings

- What are the key emerging methodological challenges for interconnection studies – e.g., new resources (storage, hybrids), changing timing of reliability concerns, load growth uncertainty?
- What should be priority areas for methods improvements?
- What is the process for implementing improvements in vendor-provided models, and how difficult is it to coordinate improvements?
- What opportunities exist for automation in interconnection studies?
- How can interconnection study methods be more transparent?
- To what extent can interconnection study methods be better harmonized across utilities? What might strategies for more harmonization look like?

Key questions we will pose (and hopefully answer)

With the audience

- How well do you understand ISO/RTO and other transmission provider interconnection study methods?
- What areas of the IX study process and/or technical study assumptions are most confusing and non-transparent?
- How important is it for developers and other stakeholders to understand these methods?
- If important, what kinds of additional steps could transmission providers take to make their methods more transparent and accessible?
- Is data access a barrier to replicating transmission provider studies and, if so, how can access be improved?
- What are the largest barriers to study harmonization?

Virtual Meetings Code of Conduct

1. *Assume good faith and respect differences*
2. *Listen actively and respectfully*
3. *Use "Yes and" to build on others' ideas*
4. *Please self-edit and encourage others to speak up*
5. *Seek to learn from others*

Mutual Respect . Collaboration . Openness

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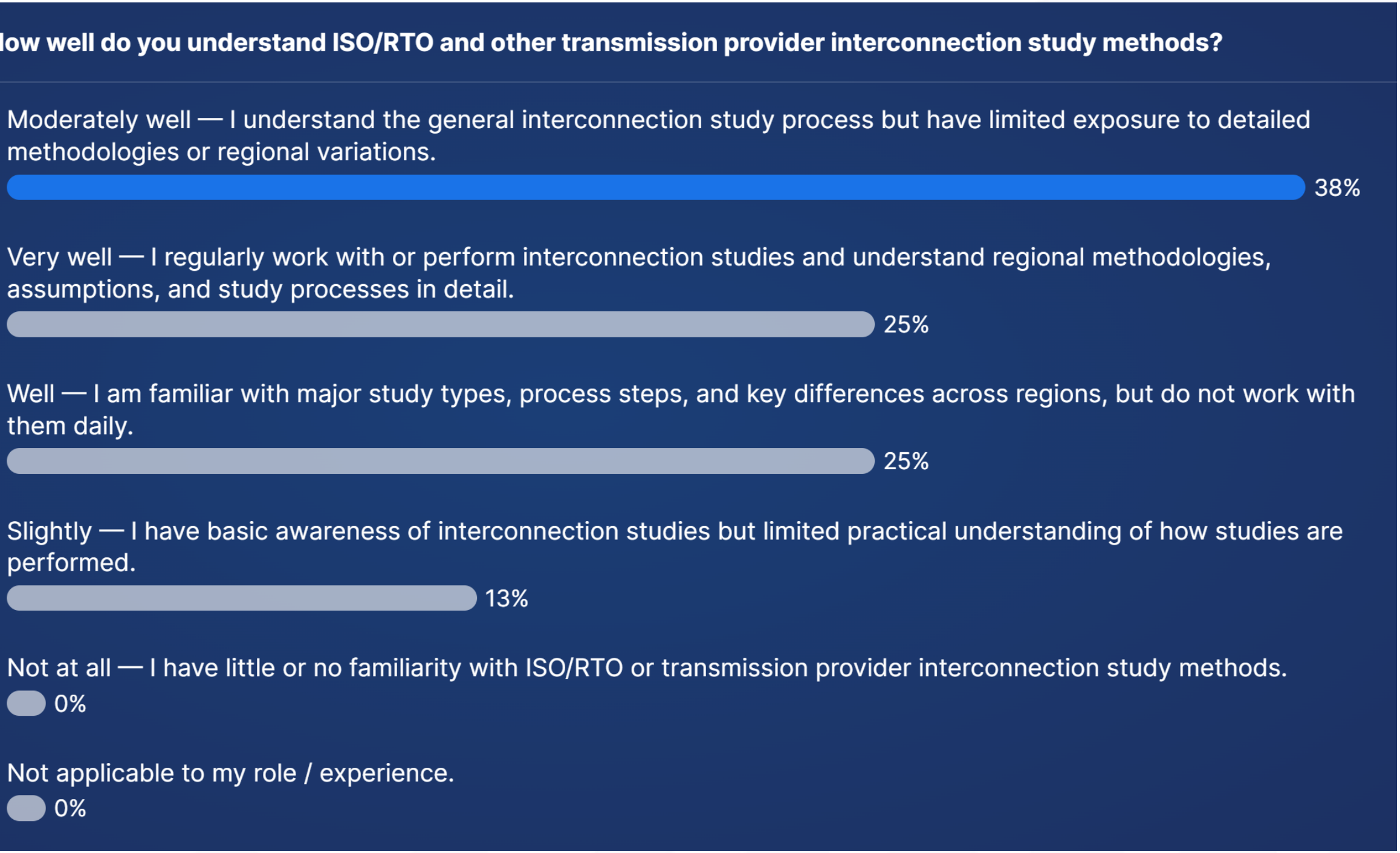
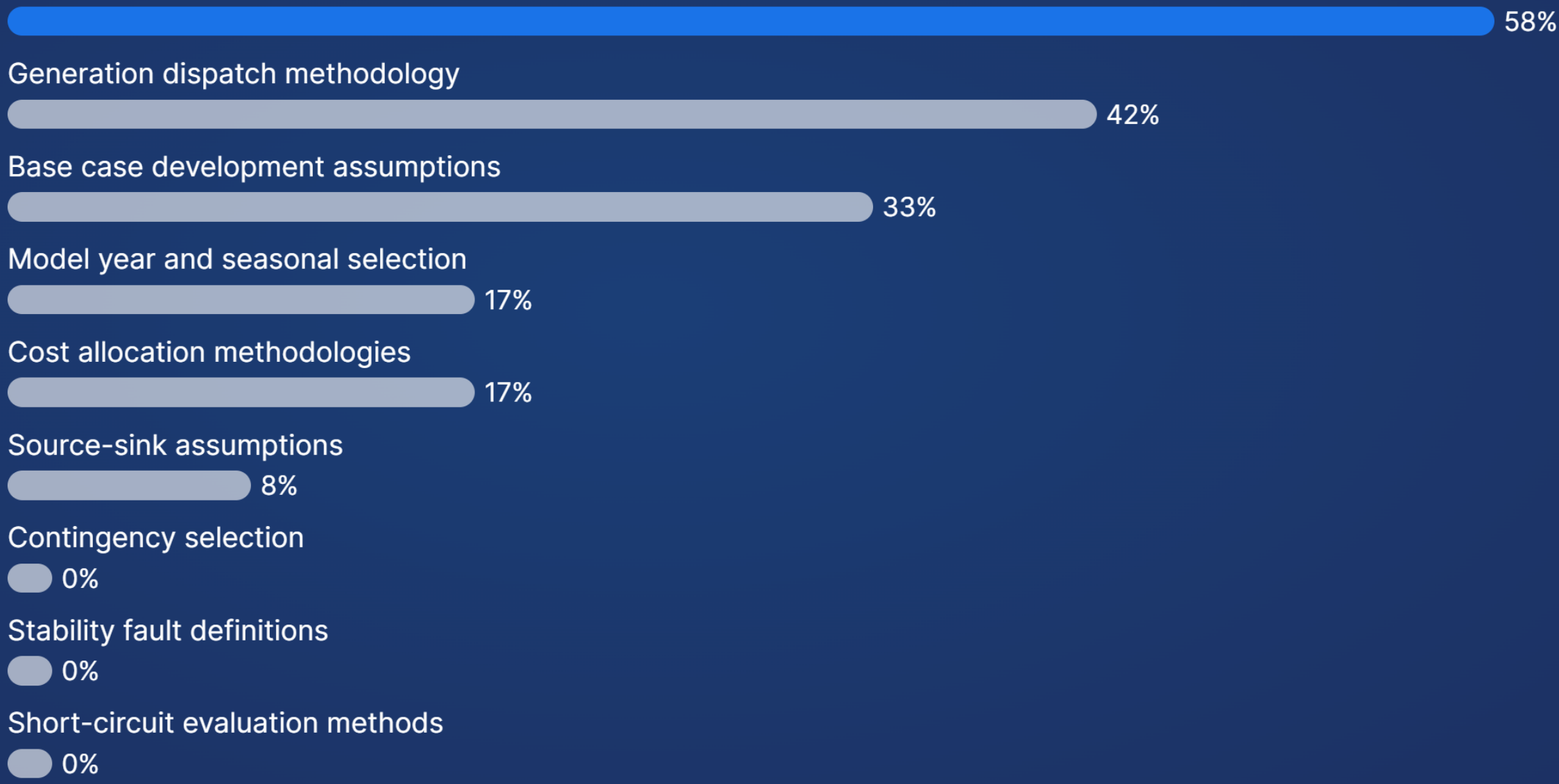
How well do you understand ISO/RTO and other transmission provider interconnection study methods?



Which ISO regions require more clarity on interconnection study processes and assumptions?

- PJM
- CAISO
- MISO SPP

What areas of the interconnection study process and/or technical study assumptions are most confusing and non-transparent?



Additional interconnection study assuptions to include in our comparison

- Transmission Owner rate of adoption of ATTs, GETs, Demand Flexibility, RAS solutions
- future tool needs
- lifecycle- equipment changes after agreement
- Transitioning to new functionalities based on changing energy landscape; e.g. implications of microgrids/bidirectionality
- Area Interchange flows
- Software and Tools used
- short circuit strength

How important is it for developers and other stakeholders to understand these methods? If important, what kinds of additional steps could transmission providers take to make their methods more transparent and accessible?

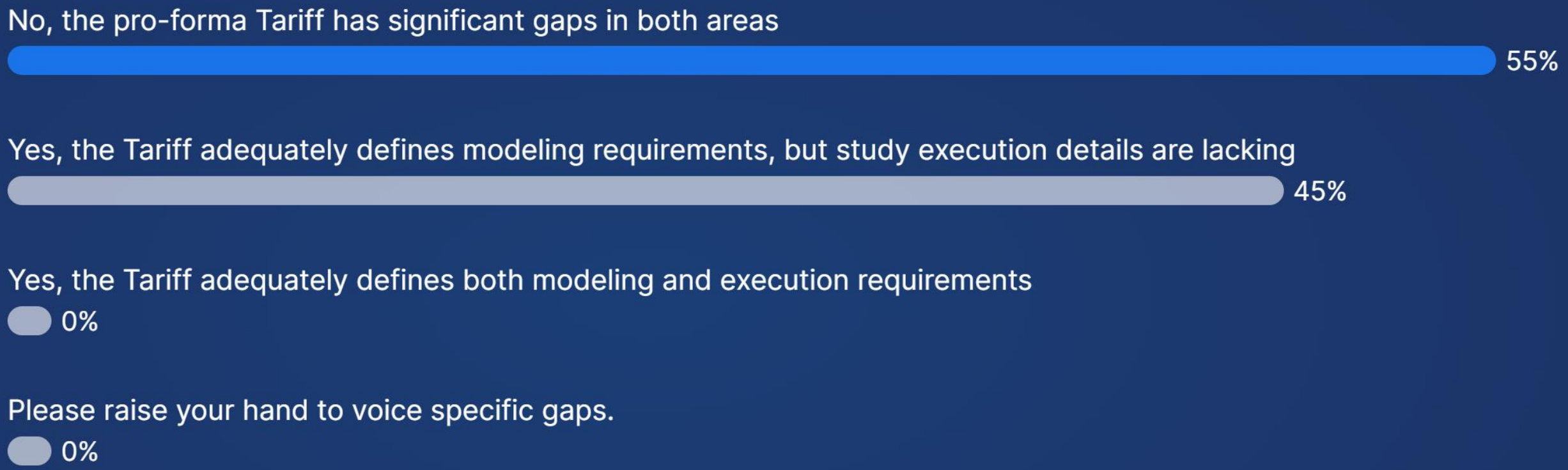
- Extremely important. Transparent study assumptions and methodologies could save significant time for utilities if developers are able to perform preliminary studies that are consistent with utility practices. Transparency increases trust and helps with opportunities for alignment and understanding of best practices.
- I think it adds understanding, so I think this is very important.
- Extremely important and go beyond accessibility and transparency to better "engagement" at different stages of processes

Is data access a barrier to replicating transmission provider studies and, if so, how can access be improved?

- Provide accurate study cases, dynamic data, and contingency files used in the studies.
- yes, super important. Affected systems comes to mind.
- yes, and extend to information-sharing, communications and governance evolution

What are the largest barriers to study harmonization? (Select up to 3)

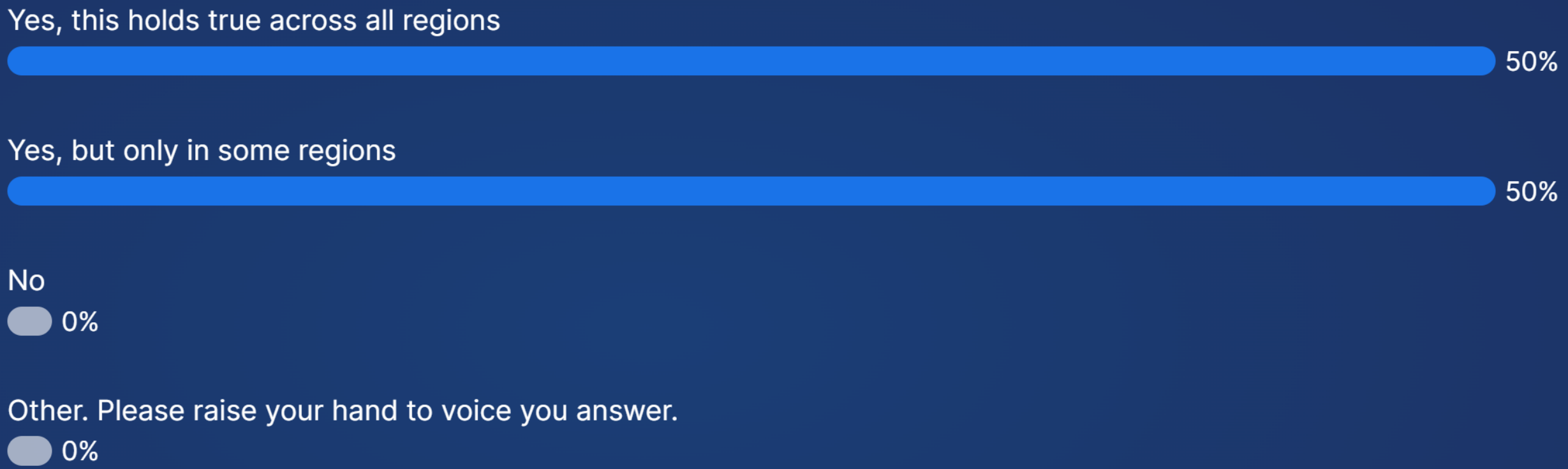
Does the pro-forma Tariff adequately define interconnection study requirements for both modeling and study execution?



Rank the following interconnection services from most conservative (1) to least conservative (4) in terms of study requirements - considering factors such as number of scenarios analyzed, breadth of NERC contingency analysis, and transfer limit analysis

1. NRIS (Network Resource Interconnection Service)
2. ERIS (Energy Resource Interconnection Service)
3. Provisional interconnection service
4. Surplus interconnection service

Do you interpret NRIS as providing a higher level of certainty of deliverability than ERIS?



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Overview of Interconnection Studies Practices: Whitepaper Framework and Objective

Sirisha Tanneeru

Lead Engineer, Transmission Planning

May 26, 2026

Purpose of the Whitepaper

- Document current interconnection study methodologies across U.S. ISOs/RTOs and select non-ISO transmission providers
- Establish a common technical reference for stakeholders
- Identify similarities and regional differences
- Support future discussions on study harmonization, transparency, efficiency, and reliability

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Background for Whitepaper

- Interconnection queues continue to experience backlogs
- Study timelines and upgrade costs have increased significantly in the last decade
- FERC Order 2023 standardized process, but did not codify technical study methodologies, assumptions, or details
- Significant variation across ISO/RTOs (and non-market entities) remains
  - Study assumptions
  - Deliverability methodologies
  - BESS charging treatment
  - Cost allocation
  - Affected system coordination

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Whitepaper Outline

- Chapter 1: Introduction and motivation
- Chapter 2: Regulatory and reliability framework
- Chapter 3: Interconnection service types and ISO/RTO process overview
- Chapter 4: Detailed comparison of study assumptions and methodologies
- Chapter 5: Conclusions
- Appendix A: Transmission provider-specific study assumption tables

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Chapter 2: Regulatory and Reliability Framework

Foundation of Interconnection Studies

- Evolution of U.S. interconnection processes
- FERC Orders 888, 2003, 845, and 2023
- Role of NERC reliability standards
- Relationship between FERC, NERC, transmission providers (ISOs/RTOs and utilities)

Core Message

- Although FERC establishes the overall interconnection process framework and NERC establishes Reliability Standards, most detailed technical study assumptions are implemented through transmission provider tariffs, business practice manuals, and planning criteria.
- The current interconnection framework is standardized procedurally, but significant variability remains in technical implementation and study methodologies.

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Chapter 3: Overview of Interconnection Services and Regional Variability

Interconnection Services Covered

- Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS)
- Surplus and Provisional Interconnection Service

Key Comparisons

The whitepaper compares transmission provider methodologies including:

- study sequencing, terminology differences
- Deliverability evaluation
- Cluster study sequencing
- Limited operation/provisional service
- Annual reassessment processes
- Treatment of storage charging

Key Takeaway

Interconnection service terminology may appear similar across regions, but implementation and study assumptions can differ materially.

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Chapter 4: Detailed Comparison of Study Practices

- For each topic, the whitepaper defines the study purpose and identifies key study inputs
- Differentiate study inputs mandated in LGIP pro-forma vs technical heuristics adopted by the Transmission Provider

Comparison of Core Reliability Study Assumptions

- Base case development assumptions
- Model year and seasonal selection
- Generation dispatch methodology
- Source-sink assumptions
- Contingency selection
- Stability fault definitions
- Short-circuit evaluation methods
- Network upgrade mitigation practices
- Cost allocation methodologies

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Example Findings – ERIS

Preliminary observations already show meaningful differences in:

- Number of seasonal cases
- Generation dispatch and sink assumptions
- Contingencies studied
- Study of BESS charging
- Identification of maximum as-available capacity
- Generator impact screening criteria - Power transfer distribution factor (PTDF)/distribution factor (DFAX)
- Treatment of constrained facilities: use of generation redispatch, Advanced Transmission Technologies (ATTs), RAS, etc.

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Visual Framework of Differences

Color-coded comparison tables in report highlight:

- Similarities and commonalities in practices
- Moderate variations across practices
- Significant methodological differences

Summary of Similarities and Differences in ERIS Study Practices

Category	Similarities	Differences
Model Year & Season	• All regions study Year 5 of the forecast horizon. • All regions apply Summer Peak as a primary study case • Additional off-peak or winter peak is evaluated to capture load variability and seasonal generation output mix (CAISO, MISO, SPP)	Number of cases developed varies significantly over the regions. • SPP develops most number of cases (28 vs 2 in most other regions). Further generation variability for high and light renewable conditions is studied for both the winter and summer seasons. • PJM uses an additional light load case
NRIS Evaluated for ERIS	• All regions evaluate NRIS for ERIS as a fundamental pre-requisite	
Study Methodology	All regions use a cluster study approach	• PJM has the most distinct study methodology: applies a probabilistic generator deliverability that treats transmission as most constrained. GD also uses harmer, EEFORD of resources to stress existing generation and transmission services and MISO schedules
Generation Dispatch	• All regions follow a fuel based dispatch for higher-queued and existing generation. • Pre study queue addition, total generation in the load serving area is held constant at the typical values targeted in the transmission expansion models: total deliverability (CAISO); CETO (PJM); MTEP LBA (CAISO). • Study queue generation is modeled at 100% interconnection service	SPP and PJM have distinct generation dispatch practices. • SPP: Zone-based fuel dispatch table (in-group vs. out-group) • PJM: Block dispatch
Generation Sink	• All regions absorb generation imbalances within a defined electrical area. • All maintain system energy balance after dispatch modifications.	• SPP: Escalating sink order if deficient: in-group PQ → Electrically Equivalent → case-by-case. • MISO: Sinks to the full Classic region (North or South). Net generation and higher-queued generation treated equally for sink. • PJM: Minimum area generation constraint tied to CETO
Contingency Events	• All regions apply NERC TPL-001-5 P0–P7 contingency categories as the baseline.	• SPP: Excludes P3 events • MISO: Studies cascading and prior outage conditions;

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Out of Scope: Not covered in the Whitepaper

- Affected System study practices
- Guidance on harmonizing differences across regions or ISOs
- Scorecard or performance ranking of individual regions
- Resource adequacy implications of interconnection service

This whitepaper is intentionally non-prescriptive. Its purpose is to document and compare existing interconnection study practices across regions, not to advocate for a single approach or evaluate regional performance.

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